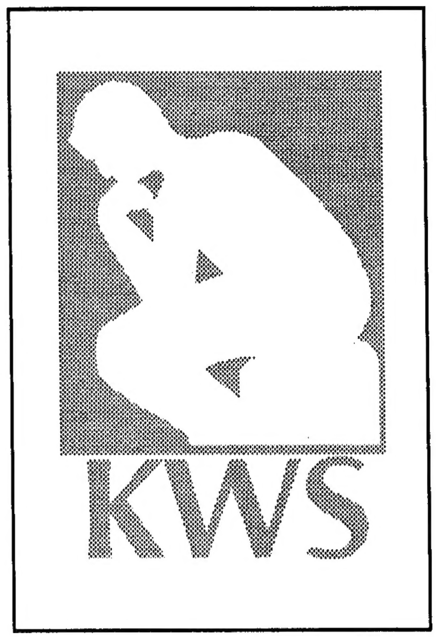
US Army Corps
of Engineers
Construction Engineering
Research Laboratories

USACERL Technical Report 95/32
September 1995

Evaluating a Performance Support Environment for Knowledge Workers

by
Beverly E. Thomas, John P. Baron, and Wayne J. Schmidt



Many Army personnel can be classified as knowledge workers—people who produce not tangible products, but some form of processed or enhanced information, often using processes that allow a high degree of individual discretion in task performance. Knowledge work is the area that offers the greatest opportunity to increase productivity within the U.S. workforce. Ongoing research at the U.S. Army Construction Engineering Research Laboratories (USACERL) is developing the Knowledge Worker System (KWS), an integrated performance support environment (PSE) designed to improve the performance of Army knowledge workers.

KWS promises to offer significant benefits. However, before installing any new system, a prospective user must evaluate whether the benefits of installation outweigh the costs, in terms of both time and resources. This study undertook to identify appropriate methods to evaluate the feasibility of implementing or continuing to use a PSE for knowledge workers, and concluded that a "toolkit" of five evaluation techniques, each applicable to a specific workgroup setting, may best assess the feasibility and usefulness of a PSE:

1. Work Profile Analysis
2. Direct to Indirect Ratio
3. Time Saved Times Salary (TSTS)
4. Activity Based Costing (ABC)
5. Quality Assessment.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

Accession For	
NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED

DO NOT RETURN IT TO THE ORIGINATOR

USER EVALUATION OF REPORT

REFERENCE: USACERL Technical Report 95/32, *Evaluating a Performance Support Environment for Knowledge Workers*

Please take a few minutes to answer the questions below, tear out this sheet, and return it to USACERL. As user of this report, your customer comments will provide USACERL with information essential for improving future reports.

1. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

____

____

____

2. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.)

____

____

3. Has the information in this report led to any quantitative savings as far as manhours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

____

____

4. What is your evaluation of this report in the following areas?

a. Presentation: ______________________________

b. Completeness: ______________________________

c. Easy to Understand: ______________________________

d. Easy to Implement: ______________________________

e. Adequate Reference Material: ______________________________

f. Relates to Area of Interest: ______________________________

g. Did the report meet your expectations? ______________________________

h. Does the report raise unanswered questions? ______________________________

i. General Comments. (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.)

____

____

____

____

____

____

5. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name: ______________________________

Telephone Number: ______________________________

Organization Address: ______________________________

____

____

6. Please mail the completed form to:

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES
ATTN: CECER-TR-I
P.O. Box 9005
Champaign, IL 61826-9005

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
September 1995

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Evaluating a Performance Support Environment for Knowledge Workers

5. FUNDING NUMBERS
4A162784
AT41
FF-AJ5

6. AUTHOR(S)
Beverly E. Thomas, John P. Baron, and Wayne J. Schmidt

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Construction Engineering Research Laboratories (USACERL)
P.O. Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
TR 95/32

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Headquarters, U.S. Army Corps of Engineers (HQUSACE)
ATTN: CEMP-MC
20 Massachussetts Ave., NW.
Washington, DC 20314-1000

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Many Army personnel can be classified as knowledge workers—people who produce not tangible products, but some form of processed or enhanced information, often using processes that allow a high degree of individual discretion in task performance. Knowledge work is the area that offers the greatest opportunity to increase productivity within the U.S. workforce. Ongoing research at the U.S. Army Construction Engineering Research Laboratories (USACERL) is developing the Knowledge Worker System (KWS), an integrated performance support environment (PSE) designed to improve the performance of Army knowledge workers.

KWS promises to offer significant benefits. However, before installing any new system, a prospective user must evaluate whether the benefits of installation outweigh the costs, in terms of both time and resources. This study undertook to identify appropriate methods to evaluate the feasibility of implementing or continuing to use a PSE for knowledge workers, and concluded that a "toolkit" of five evaluation techniques, each applicable to a specific workgroup setting, may best assess the feasibility and usefulness of a PSE:

1. Work Profile Analysis
2. Direct to Indirect Ratio
3. Time Saved Times Salary (TSTS)
4. Activity Based Costing (ABC)
5. Quality Assessment.

14. SUBJECT TERMS
Knowledge Worker System (KWS)
Performance Support Environment (PSE)
computer programs

15. NUMBER OF PAGES
68

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

Foreword

This study was conducted for the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE) under Project 4A162784AT41, "Military Facilities Engineering Technology"; Work Unit FF-AJ5, "Performance Support Environment Effectiveness." The technical monitor was Erica Ellis, CEMP-MC.

The work was performed by the Business Processes Division (PL-B) of the Planning and Management Laboratory (PL), U.S. Army Construction Engineering Research Laboratories (USACERL). Moonja P. Kim is Acting Chief, CECER-PL-B, L. Michael Golish is Acting Operations Chief, and David M. Joncich is Chief, CECER-PL. The USACERL technical editor was William J. Wolfe, Technical Resources Center.

COL James T. Scott is Commander and Acting Director of USACERL, and Dr. Michael J. O'Connor is Technical Director.

Contents

List of Tables and Figures

Tables

Figures

1 Introduction

Background

Many Army personnel can be classified as knowledge workers—people who produce not tangible products, but some form of processed or enhanced information, often using processes that allow a high degree of individual discretion in task performance. Knowledge workers make decisions that significantly impact organizational resources and are themselves a significant and costly resource; knowledge workers compose 43 percent of the white-collar sector, which in turn comprises 67 percent of the service sector (Roach 1991).

Knowledge work is the area that offers the greatest opportunity to increase productivity within the U.S. workforce (Drucker 1974). Ongoing research at the U.S. Army Construction Engineering Research Laboratories (USACERL) is developing an integrated software program designed to improve the performance of Army knowledge workers. The Knowledge Worker System (KWS) is a computer-based performance support environment (PSE) designed to document, coordinate, and execute the business processes assigned to workgroups. KWS is an integrated set of automation systems that guides Army action officers through the course of their daily tasks by helping them organize, prioritize, and execute their work efficiently and effectively. KWS can help meet the need for a wide range of functional process improvements and training requirements by providing institutional knowledge on an as-needed, individualized basis.

While KWS promises to offer significant benefits, installing any new system involves a commitment of both time and resources that must justify itself economically; i.e., benefits must outweigh costs. Part of the KWS research effort is to identify appropriate metrics that indicate the impact of the system on workgroups. This study undertook to investigate techniques to measure whether the implementation and/or continued use of a PSE for knowledge workers such as KWS is justified.

Objectives

The objective of this research is to identify appropriate methods to evaluate the feasibility of implementing, or continuing the use of, a performance support environment for knowledge workers.

Approach

A broad review of literature in productivity measurement was conducted, including areas such as white collar productivity, organizational psychology, information economics, industrial engineering, economics of technology, quality management, and decision theory. Several techniques for productivity measurement were evaluated for their applicability to the environments in which Army knowledge workers operate.

Mode of Technology Transfer

The findings from this study will be incorporated into future USACERL work units that address the development of the Knowledge Worker System.

2 Issues in Evaluation

"What gets measured gets attention, particularly when rewards are tied to measures."
(Eccles, in Helton 1992)

Why Measure

"Productivity" is a fairly intuitive notion that can be defined as the relationship of the outputs to the inputs used in production (National Research Council 1994). If outputs and inputs are well quantified, that relationship might simply be defined—and compared—mathematically, as output divided by input (Sink 1984).

The goal of productivity measurement is to determine whether organizations can obtain the same output with fewer resources, or increase output while holding resource levels constant (Lau 1988). With this goal in mind, three reasons for evaluating productivity are:

1. To identify potential improvements
2. To determine how to allocate resources
3. To determine how well organizational goals are being met (Sardina and Vrat 1987).

Within the Federal government, the Bureau of Labor Statistics monitors productivity by collecting output measures, identifying resource requirements, and determining estimated production goals (Forte 1992). Objective measures of output, resource levels, and production goals are benchmarks that form a baseline to compare and improve productivity levels. Without such benchmarks, organizations could not set goals or allocate resources since, "without productivity objectives, a business does not have direction. Without productivity measurement, it does not have control" (Drucker 1974). It is this baseline of knowledge worker productivity that must be determined (Bridges 1992).

Problems in Evaluating Knowledge Work

Measurement and evaluation of knowledge work is a difficult problem (Drucker 1974; Magliola-Zoch 1984; Rittenhouse 1992; Sassone 1991; Sink 1985; Thomas and Baron 1994). Many of the problems relate to the very nature of knowledge work: its inputs are not clearly definable; it generates intangible outputs; and it allows a high degree of discretion on the part of the performer (Beruvides and Sumath 1987). Knowledge work is often complex and nonroutine, and commonly requires the contribution of several people to complete a given task. All these characteristics make norms and standards difficult to establish, and performance hard to measure.

The net results of this complexity is disagreement about what to evaluate. Frequently, inappropriate metrics are applied to knowledge work simply because the particular indicator in use is easy to quantify (Rittenhouse 1992). The essential component of *quality* is often ignored due to the difficulty in measuring this attribute.

In 1994, the National Research Council commissioned a committee to investigate the apparent meager increases in productivity in the service sector, despite the large amounts of money spent on information technology for this group. The committee concluded that, to a large degree, these disappointing productivity results arise from inappropriate metrics:

> Productivity data do not capture important elements of service output. Key among these are the capacities to handle increased complexity and to provide improved timeliness, flexibility, response times, reliability, or safety for employees, customers, or the general public.

If these and other factors are accounted for, the resulting figures might demonstrate a strong increase in service-sector performance through information technology investments (Peterson 1994, p 7).

Individual vs. Group Measures

Rittenhouse (1992) and Sassone (1991) identify the workgroup as the appropriate level at which to measure the performance of knowledge workers. Rittenhouse observes that individual measurements are not particularly useful since increases in an individual's productivity does not necessarily transfer upward within an organization. For this reason, this study concentrated on group evaluation.

Several practicioners recommend the use of a family of measures. The director of quality measurement and improvement at USAA has credited the ability to track both individual performance (in some categories) and group performance (in others) as a factor in the organization's finalist position in the Malcolm Baldridge National Quality Award for multiple years (Helton 1992).

Helton (1992) recommends an approach that includes the following steps: (1) select the group involved in the work to be tracked, (2) help this group select several measures appropriate to the work, (3) help the group clearly define the measures, frequency of measurement, and whether benchmarking is appropriate, and, (4) document the results.

3 Evaluation Strategy

Suggested Approach

In earlier work, Thomas and Baron (1994) concluded that knowledge work performance measurement required special evaluation techniques. No single technique is appropriate for all types of knowledge work. The authors suggested that the first step in performance measurement within knowledge work environments was work categorization. Thomas and Baron identified eight components of knowledge work relevant to categorizing work groups:

1. Decisionmaking
2. Complexity
3. Knowledge use
4. Structure
5. Repetition
6. Volume
7. Time per job
8. Skill level.

This earlier work suggests that a "toolkit" of evaluation techniques is appropriate to evaluate the feasibility of a performance support environment for knowledge workers. Industrial engineering, industrial management, and operations research have yielded a variety of evaluation techniques, each applicable to specific work group settings.

Before determining which techniques fit a particular work group, the first step should be to categorize the type of knowledge work performed within that environment. Reducing the eight work components to four key components reduces the categorization effort, while still maintaining clear and useful categories:

1. *Complexity* incorporates the first three of the original eight components (decisionmaking, complexity, and knowledge use). Issues relevant to evaluating the degree of complexity in a process include: how much knowledge is applied in this process; how much thought must be applied to perform the job; and how much information is required to complete the process.

2. *Volume* reflects the number of times a targeted activity occurs within a given time frame. Issues relevant to evaluating the volume level are: whether the activity is performed frequently within a month, a week, a quarter, or a 1-year span.

3. *Time per job* is the time spent completing the job, start to finish. When evaluating this component, the issue is whether the relative time spent on each task is high, medium, or low.

4. *Repetitions* indicate the frequency with which a process is performed. Evaluating this attribute involves how often the same process is repeated (i.e, performed without variation from previous occurrences).

The remaining two components, *Structure* and *Skill Level*, can be eliminated from work categorization exercise without sacrificing meaningful results since structure appears to vary significantly within knowledge work environments and skill level is more relevant to blue-collar work environments than to knowledge work.

Helton (1992) suggests four criteria for the categorization of knowledge work:

1. *Work Range* means the scope of the work performed. Questions to ask when evaluating the work are: Are tasks repetitive? Are tasks cyclic?

2. *Work Structure* indicates whether work objectives are shifting or fixed. A question to ask: How changeable are work goals?

3. *Control* reflects the degree of discretion allowed. Some questions to ask include: How planned is the work? How much freedom of choice is allowed in how, when, or where the work is done?

4. *Cognitive Effort* indicates the degree of reasoning difficulty used to solve work problems. Cognitive effort can be ranked as: very substantial, substantial, intermediate, or limited.

Helton uses these criteria to classify work into one of four types of white-collar work: Specialist, Professional, Support Staff, and Clerical Staff (Table 1). Helton's categories correspond roughly with the suggested framework: Work Range correlates with Time per Job; (2) Work Structure correlates with Volume and Repetitions; (3) Controls correspond with Structure, and (4) Cognitive Effort correlates with Complexity.

Table 1. Principle attributes by white-collar work type.

Work Range	Specialist*	Professional	Support	Clerical
Non-repetitive	P	P	S	
Repetitive		S	P	P
Non-routine	P	P	S	
Routine			P	P
Individual	P	P		
Group		S	E	S
Sequence-Dependent			E	P
Work Structure				
Shifting Objectives	P	P	S	
Fixed Objectives		S	P	P
Control				
Discretionary	P	P	S	S
Non-discretionary			P	P
Cognitive Effort				
Very Substantial	P	S		
Substantial		P		
Limited			E	P

*P = primary; S = secondary; E = either

Selection of Evaluation Techniques

Table 2 and Figure 1 show how work is categorized by four work components to identify three resulting types of work environments: Knowledge Work, Production Office, and Proceduralized Work (formerly called blue collar work). Each of these environments exhibits a range of values for each of the four work components. Proceduralized (blue collar) Work is included only as a point of comparison with the two knowledge work environments.

Once a work group has been categorized by the four composite knowledge work attributes, the next step is to choose an appropriate evaluation tool. The workgroup itself must participate in establishing the particular metrics to be used for evaluation. Besides being the best judges of appropriate metrics, the more involved the group is, the less its members are likely to feel threatened by the study (Anthony 1984; Bernard 1986).

Table 2. Work type categorized by component and degree.

	Complexity			Time per Job			Repetitions			Volume per Worker		
Component Level ->	H	M	L	H	M	L	H	M	L	H	M	L
Knowledge Work	X	X		X	X			X	X		X	X
Production Office		X	X		X	X	X	X		X	X	
Proceduralized Work		X	X	X	X		X	X			X	X

Information Economics

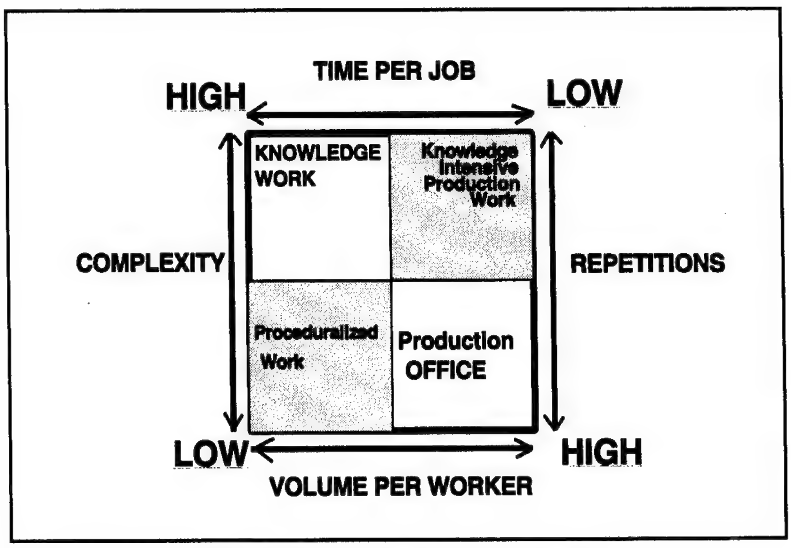


Figure 1. Work categorized by four work components.

Economists Parker, Benson, and Trainor (1988) proposed Information Economics (IE) as a framework that quantifies and weights intangible benefits and costs of information technology (IT) alternatives. IE is intended as an approach for evaluating an organization's IT investments.

Standard cost-benefit analysis, the conventional tool for evaluating IT projects, is based on accounting-type data such as projected costs and benefits, and estimated return on investment (ROI). However, this standard approach ignores a number of factors that may determine the success or failure of a project simply because these factors do not lend themselves to dollar quantification. Traditional cost-benefit analysis is not adequate for evaluation of innovative systems such as performance support environments (Parker, Benson, and Trainor 1988).

Information Economics can be defined as a collection of computational tools that allow rational comparison of benefits and costs of IT projects. Parker, Benson, and Trainor claim that IE goes beyond cost-benefit analysis by providing a decisionmaking structure that separates information technology justification from technology feasibility for a particular project. In other words, IE allows an organization to make two important distinctions: (1) what this project is worth to the organization, and (2) whether the organization has the resources necessary to complete the project. In

terms of justifying a PSE, Information Economics is valuable mainly because of the tools it provides for determining an answer to the first question.

Figure 2 shows how IE focuses on value rather than the more limited concept of benefit and hard dollar savings. The model expands the traditional cost-benefit analysis to include quantification of intangible benefits and risks of both business and technical issues. Dollar savings are important, but intangible elements such as increased knowledge worker productivity, improved communications, and enhanced quality should be evaluated by organizations as they make IT decisions. IE typically suggests six classes of value:

1. *Enhanced ROI* is similar to standard return on investment but expanded to include additional methods (value acceleration, value linking, and value restructuring).

2. *Strategic Match* is a measure of how closely aligned the project is to the organization's strategic goals.

3. *Competitive Advantage* estimates the degree to which the project provides an advantage in the marketplace, and can be viewed as an improvement in the product or service of the organization, or as a sharpening of the focus of its vision.

4. *Management Information* reflects the value of the information, or the improved information that the project is expected to provide. The more essential to the functioning of the organization the project's information is, the higher its value.

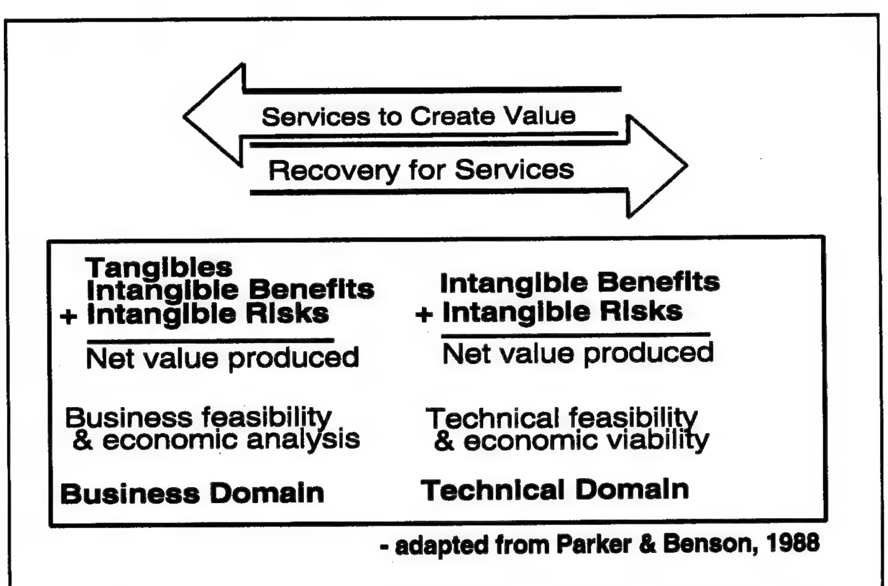


Figure 2. Information economics.

5. *Competitive Response* is an estimate of the consequences of not implementing the project. (This is another class of value that has direct reference to nongovernmental organizations in that it relates to the market share and related issues. However, there can be many consequences of not implementing projects in the government. This can be viewed as the nonmarketing consequences of inactivity. An organization that appears unable to handle its work effectively may no longer have that work to do or it may find itself reorganized into some other organization.)

6. *Strategic IS Architecture* assumes that there is some strategic plan for the information systems of the organization, and is used to measure how the project fits into and/or complements that overall plan.

Each of these value classes is assigned a weight for the organization in which the IE analysis is occurring. Eventually, every proposed project will be evaluated in each value class for its effect and then a summarized score is calculated for each project.

In applying IE concepts in a cost-benefit analysis, an organization typically begins from its business vision and then establishes criteria and weights that can be used in deciding which IT investments best fit the vision. When applying IE to the justification of a PSE, the starting point is a set of potential benefits that can be attributed to implementation of the PSE. Consider the following example:

> PERFECT Company places great value on never making a mistake on a customer's order. Their vision is focused on this error-free goal. Their evaluation of any project will weigh heavily its effect on perfection. CHEAP Company on the other hand takes great pride in offering the cheapest price on the market. Consequently, this company will weigh any project heavily for its effect on price.

This example shows that what the user deems important must be established as a first step in evaluation. Once an evaluation team has determined what the user finds important in a potential IT project, the selection of appropriate tools and measures will follow. In the example, the overriding concern of the PERFECT Company is perfection. Logically, the business will look for measures that reflect the level of perfection.

Suppose IE is applied to the justification of KWS. One of the benefits of KWS is an improvement in scheduling efficiency. If one member of the evaluation team rates this benefit as very important, then one of the metrics for determining KWS success for this rater will be the improvement of scheduling. A point central to the IE concept is that justification of IT is based on factors important to the IT user.

There are four steps in performing the IE-derived cost-benefit process:

1. Identify tangible and intangible benefits/risks.
2. Assign relative weights to each identified benefit and risk.
3. Rate each benefit and risk in terms of importance to the organization.
4. Total the individual scores and identify which alternative has the highest sum. Document the rationale behind each ranking and weight to create an audit trail of the decisionmaking process.

The application of IE cost-benefit analysis to the evaluation of a performance support environment follows the same four-step procedure. The group that performs this analysis should be comprised of representatives of top management and personnel who will primarily use the PSE.

The value classes supported by the PSE must be identified. The following classes are proposed:

- *Enhanced ROI* includes any of the following items:
  - cost avoidance
  - reductions in operating costs.

- *Performance Improvements* addresses any of the following items:
  - improved timeliness
  - improved quality
  - improved decisionmaking.

- *Strategic Match* is a measure of how closely the PSE aligns with the organization's strategic goals.

- *Strategic IS Architecture* is a measure of how the proposed PSE fits into and/or complements the organization's overall strategic plan for the information systems. In the absence of a plan, this factor may be evaluated in accordance with:
  - long-term support requirements
  - disruption to business during start-up period
  - on-going training requirements.

The major benefits of the PSE must be clearly identified. The key KWS benefits are:

1. *Improved Effectiveness* increases intellectual specialization within the organization, and is sometimes referred to as "doing the right thing."

2. *Reduced Rework* decreases the amount of work that must be redone due to error.

3. *Improved Efficiency* means that the same work can be accomplished in less time, and is sometimes referred to as "doing the thing right."

4. *Improved Focus* makes more time available to devote to the primary mission or function of the workgroup, rather than to tangential activities.

5. *Work Elimination* allows KWS either to eliminates the need for some tasks or to accomplish them automatically.

The worksheet shown in Figure 3 reflects these proposed value classes and the KWS benefits. The key point for the justification of a PSE using the IE concept of cost-benefit analysis is to perform this type of analysis at the beginning of the project. Use the results of the IE analysis to: (1) gain consensus among management and primary users about the expected benefits, (2) influence the choice of performance metrics and, (3) create an audit trail of the information and decisions that initiated the PSE.

Appendix A provides a taxonomy of KWS benefits, capabilities, and functions as well as an explanation of the worksheet example used here. Appendix B gives more information on Information Economics.

VALUE CLASSES

	Value Code	Value #	Name
Importance of the value to the organization		1	ENHANCED ROI
		2	PERFORMANCE IMPROVEMENTS
		3	STRATEGIC MATCH
		4	STRATEGIC IS ARCHITECTURE
		5	
		6	

KWS BENEFITS

Relation to numbered value 1	2	3	4	5	6	Benefit Ltr.	Name	Ind Benefit Scores
						A	Improved Effectiveness	0
						B	Reduced Rework	0
						C	Improved Efficiency	0
						D	Improved Focus	0
						E	Work Elimination	0
						F		0
						G		0
						H		0
						I		0
						J		0
						K		0
						L		0

SCORE FOR KWS IMPLEMENTATION 0

EXPLANATIONS OF CODES

Relation Codes

0 No Relation
1 Minimal Relation
2 Some Relation
3 Moderate Relation
4 Strong Relation
5 Absolute Relation

Value Codes

0 Not Relevant
1 Not Important
2 Little Importance
3 Moderate Importance
4 Important
5 Very Important

Figure 3. Scoresheet for KWS Implementation.

4 Toolkit of Evaluation Techniques

Several techniques should be included in a toolkit for evaluating the feasibility of implementing a PSE for knowledge workers. Each technique is described here.

Work Profile Analysis

Work Profile Analysis is part of the hedonic wage model, as applied to the justification of an office information system (OIS) by Peter Sassone (1987, 1992, 1992). This application of the hedonic wage model assumes that an OIS can both decrease the amount of time required to complete a given task and facilitate restructuring of work assignments. Both of these changes are postulated to result in higher efficiency. Professionals have more time to perform work in their specific specialties and spend less time on routine and/or nonproductive tasks. The combination of the OIS and restructuring within an office can correct the misallocation of time spent by white-collar professionals on lower-value activities.

The premise of the hedonic wage model, as applied to OIS, is that the value of an information system originates in the value of the activities performed by the intended OIS users and how the target system improves work patterns. This premise matches the purposes of a PSE for knowledge workers and applies to the task of evaluating the impact of a PSE.

A key component of the Sassone's application of the hedonic wage model is the Work Profile Analysis (also referred to as Work Value Analysis), which is based on the concept of intellectual specialization within knowledge work. The approach begins with a baseline analysis of work patterns in an office before introduction of an OIS. After the OIS is implemented, work patterns are resurveyed. Comparing the "before" and "after" work pattern snapshots provide the basis for identifying the impact of the system.

Sassone explains the concept of intellectual specialization as follows. Organizations generally pay their personnel on the basis of the intellectual content of the work each employee is capable of doing. Personnel with great experience are compensated at a higher rate than inexperienced personnel. Likewise, employees with advanced degrees

are paid more than those with lesser degrees. Engineers, for example, are paid more than secretaries.

Consider, however, that employees do not spend 100 percent of their work time doing the kind of work their background qualifies them to perform. Knowledge workers may spend only a small portion of a work day working in their area of expertise. Most knowledge workers exert much of their work effort doing tasks that could be delegated to less skilled, less expensive employees (Sassone 1992).

A Work Profile Analysis can indicate how knowledge workers at various levels within an organization typically spend their time. By calculating the typical number of hours worked and the total cost of each type of work, the actual cost of each type of knowledge work within a specific organization can be figured.

The steps in creating a Work Profile Analysis are to: (1) categorize the work, (2) survey the employees, (3) develop a matrix analysis, (4) implement the system under study, (5) resurvey employee, (6) compile a second matrix analysis, and (7) compare the baseline and second matrices to evaluate the impact of the information system.

The purpose of work categorization is to classify work performed by specific workgroups. This phase is accomplished by reviewing mission statements, job descriptions, and interviewing (both management and nonmanagement) personnel. The workgroup's tasks are decomposed to the lowest level to which each can be delegated. Tasks are then consolidated to produce an averaged grouping of functions. The output of this step is a survey instrument.

In the survey step, each workgroup member logs data that indicates how much time he or she spends within each category of work. In Sassone's studies, each knowledge worker recorded information hourly in response to the question: "How many minutes did you spend in each of the pre-defined categories of work?"

A matrix analysis is created by gathering data from the surveys and compiling the information into a matrix that indicates the workgroup's intellectual work distribution by organization position. This matrix will serve as a baseline for the workgroup under study. For example, the information gathered from the surveys (and initial interviews) is compiled into a preliminary matrix (Table 3) that shows distribution of effort within each staffing level. This information will serve as a baseline for the workgroup under study.

Table 3. Baseline matrix of occupation type by work type actually performed.

Position	Managerial	Professional	Support	Non-Productive
Managerial	30%	20%	20%	30%
Professional	5%	35%	35%	25%
Support	0	0	75%	25%
Total	5%	15%	55%	25%

Matrix Analysis I

Table 3 shows that managers spend 30 percent of their time performing managerial work, (e.g., planning, personnel work, budgeting, upward reporting), 20 percent of their time in professional work (e.g., preparing technical presentations, writing technical reports, technical analysis), 20 percent of their time in support work in support tasks (e.g., clerical tasks, fixing hardware or software, filing, photocopying, or keying in data). The remaining 30 percent of their time is spent on nonproductive tasks (e.g., looking for information, waiting on people or equipment, playing telephone tag, walking between buildings).

Following Sassone's approach, the office information system is implemented and allowed to operate long enough that all start-up effects are over. Once the system is in its operational stage and system benefits can be realized, the workgroup is resurveyed. Results of this second survey are compiled into the second matrix. Employees are resurveyed at that time to produce a post-implementation matrix analysis.

Matrix Analysis II

The second matrix (Table 4) shows that the overall distribution of time within each category of work has changed. The implication is that managers accomplish more higher-level functions—the desired effect. Assuming that managers and senior professionals are paid higher salaries than support personnel, the organization can realize an economic gain from this shift.

Table 4. Baseline matrix of occupation type by work type actually performed.

Position	Managerial	Professional	Support	Non-Productive
Managerial	60%	20%	10%	10%
Professional	15%	55%	15%	15%
Support	0	0	80%	20%
Total*	10%	30%	45%	15%

The results of the Work Profile Analysis can be used to evaluate the impact of the OIS. The results may also indicate the need for additional support personnel or other restructuring within the office. As Sassone has written, many organizations have managers and highly-skilled professionals who spend too little time in work requiring their expertise. Often, much of the professional's time is spent in work that could be delegated to lower-paid employees. In many cases, restructuring the office or work-group can correct this problem.

Specifically, there are often insufficient numbers of secretaries and/or clerks to handle the volume of clerical work required. Hiring additional clerical help or otherwise restructuring the environment is usually a less expensive alternative than paying higher-skilled workers to perform these tasks (Sassone 1992).

Work Profile Analysis can be accomplished in a PSE via an automated or manual tool. USACERL has created a software instrument that achieves the time logging phases of the methodology (summarized in Appendix C). The other steps, work categorization and development of the work matrix, must be performed manually. Alternatively, the entire process can be performed manually, as in Sassone's studies (Sassone 1992). Appendix D to this report gives instructions and a sample dictionary of work categories derived for knowledge workers at an office in Headquarters, U.S. Army Corps of Engineers (HQUSACE).

Computation of Direct to Indirect Work Ratio

A second possible approach to evaluating the impact of a PSE computes the amount of time spent on direct vs. indirect work. Direct work is defined as those activities required to generate mission-related products. Indirect work includes tasks that support personnel performing mission-related work. The concept of direct versus indirect work originated in manufacturing. In industry, direct work denotes production labor; indirect work refers to labor that supports production. In a factory setting, an employee's work is considered as either 100 percent direct or indirect labor. If a worker is in operations or production, that employee's work is classified as direct. Maintenance or clerical work is automatically considered indirect.

The distinction between indirect and direct is more difficult in knowledge work. White-collar professionals can perform both types of tasks. In a knowledge work setting, indirect work includes activities such as photocopying, upward reporting, personnel management, filing, and responding to requests for information. Both classifications of work are necessary, but the organization is best served if most of a knowledge worker's time is spent on direct work.

Since knowledge workers may create goods or services, the same employees are often responsible for many indirect assignments, such as upward reporting, paperwork, distribution of information, and personnel management tasks. Each workgroup within an organization must find the appropriate balance between direct and indirect work (Helton 1993).

One advocate of this approach suggests that knowledge workers should strive to spend approximately 60 percent of their time in direct work. Helton recommends performing organizational alignment, a process in which the mission or purpose of the organization is closely coupled with how work time is spent. He suggests that employees who spend more time doing value-added work benefit both the organization and themselves. Measures that focus work effort and expedite work performance can result in continuous improvement within the organization (Helton 1991).

Helton's approach would track several trends: (1) the amount of direct work time, (2) the amount of indirect work time, (3) the ratio of direct vs. indirect work time, and (4) the ratio of direct to total work time. Comparison of the ratio of direct vs. indirect work prior to and following the introduction of a PSE may yield a useful indicator of the system's effectiveness.

Helton's approach does not emphasize the industrial engineering focus on measuring activities, but rather concentrates on direct work and speeding up work processes. He states that direct work adds value to an organization by expediting the accomplishment of the business-related, tangible outputs. By emphasizing direct work and therefore the mission of the organization, knowledge workers are encouraged to spend their time and effort on strategic business objectives.

To apply these concepts to the evaluation of a PSE, the implementation team that collects process information prior to introduction of a PSE can be tasked to identify situations where direct versus indirect measures are easily discernible. A workgroup with one major purpose is a likely candidate for calculation of direct-indirect work ratios.

For example, an organization's travel office has a clear mission: to make travel arrangements for organizational personnel. If the travel office agrees that the number of travel orders processed quarterly is a good measure of their productivity, this data should be targeted for pre- and post-implementation collection. The implementation team should identify all tasks that pertain to the production of travel orders, which will serve as the basis of the direct work figure. The team must ascertain how many staff hours are spent on work related to travel orders before the introduction of the PSE. Any staff time spent on work not related to the production of travel orders is

figured as indirect work. The direct versus indirect work ratio can be calculated as the percentage of staff time spent on travel order production relative to the percentage of staff time spent on other work.

A PSE installation generally requires an implementation team that is responsible for collecting process information for the site. The implementation team should examine tasks that comprise indirect work as possible Process Improvement Possibilities (PIPs). Indirect work tasks may be PIP candidates that should be eliminated, automated, streamlined, or subjected to other process re-engineering activities.

After identifying direct work tasks and collecting the number of hours spent on direct work, calculate the percentage of direct work time (staff hours spent on direct work divided by total staff hours). Likewise, figure the indirect work percentage (staff hours spent on indirect work divided by total staff hours). A direct to indirect ratio of 1.5 to 1 has been suggested as a reasonable target for most professional organizations (Helton 1991).

The post-implementation measurement is taken after the PSE is fully implemented. After the staff has been completely trained and the start-up costs of initiating a new system have been realized, the direct vs. indirect work ratio should be recalculated to determine if the ratio has improved.

Time Saved Times Salary

The Time Saved Times Salary (TSTS) technique examines labor efficiency gains that can be attributed to the implementation of a PSE. The approach is straightforward; gains in efficiency are multiplied by labor cost.

For example, if a task that took 4 hours to perform before implementing a PSE can completed in 1 hour after system implementation, then a time savings of 3 hours per task performance can be calculated. If the task is required monthly, time savings of 3 hours per month or 36 hours yearly is realized. To calculate an annual TSTS figure, 36 hours is multiplied by the hourly salary of the knowledge worker who normally performs the task.

Estimates of task duration must be recorded before system implementation for the TSTS technique. Documentation of task durations should be the responsibility of the implementation team that collects process information. It is important to ask personnel who actually do the task how long performance takes. Ask task performers to differentiate between elapsed time and time actually spent on the task, from start-

to-finish. A change in task performance can affect either or both figures. Interview personnel to determine *volume* (the number of times a targeted activity occurs within a given time frame) and *repetitions* (the frequency with which a process is performed). These questions must be asked prior to system implementation to get accurate task durations. Once the task has been automated or the process streamlined, any estimates of duration will be less reliable. Intuitively, the duration of a task is easier to recall before changing the task.

An additional application of this data addresses the selection of PIPs. Tasks that have long durations, frequent iterations, and/or high volume are high-priority candidates for PIPs. These are tasks that may yield a high pay-off in efficiency gains and therefore should be examined for automation, streamlining, or other process improvements.

The final step in TSTS is taken after the PSE is fully implemented. Some time following the introduction of the PSE, after the start-up costs of initiating a new system have been realized, post-implementation task performance data must be collected. Tasks that were targeted as PIPs should be examined to determine if (1) duration, (2) frequency, and/or (3) volume have changed following the PSE implementation. These data can be collected via interview or survey. Alternatively, the PSE can be constructed to collect the required data.

Activity Based Costing

Activity Based Costing (ABC) is a cost accounting method that attempts to allocate the actual cost of providing a service or producing a product. ABC differs from traditional accounting practices that allocate all indirect costs through somewhat arbitrary accounting rules. Traditional accounting techniques generally link all overhead costs to products or services on the basis of direct labor costs.

According to conventional accounting rules, a service that generates 10 percent of the total direct labor costs for an organization would also be allocated 10 percent of all overhead costs. ABC attempts to allocate costs to the services or products that generate these costs. ABC was derived from a manufacturing model that defines production as a set of predefined activities. The activities consume resources, which generate costs. By allocating a product (or service) to a set of activities with an incumbent set of resources and costs, a realistic cost of generating the product or service can be calculated.

The following example illustrates the ABC approach (Liggett, Trevino, and Lavelle (1992). Consider a company that produces two products: gadgets and widgets. Four employees are responsible for performing all work. Two employees spend 100 percent of their time in assembling the components required to produce the gadgets and widgets. The other two employees spend 70 percent of their time inspecting the component parts and finished products, and 30 percent of their time in material handling.

Each employee costs the company $10 per hour, including all fringes. During the course of 1 year, 1.3 million components are received and assembled into finished products. One million tests are performed to inspect the parts and finished products. Components are moved from storage into the assembly stations in batches of 50. The distance traveled for retrieval of each gadget component is 250 ft; for widgets, the distance traveled is 40 ft (1 ft = 0.305 m). Gadgets require four components; widgets require six. Seven tests are conducted for each gadget produced; two tests are conducted for each widget. Annual gadget production is 100,000 units; annual widget production is 150,000 units.

Using this data, unit cost values for gadgets and widgets can be constructed using the ABC paradigm. There are three activities in producing the two products: assembly, inspection, and material handling. The cost drivers for each activity are: (1) assembly – number of components assembled, (2) inspection – number of tests conducted, and (3) materials handling – number of feet the components are moved.

Tables 5 through 9 give a summary analysis of the process. Table 5 links the products to the activities through cost drivers. Table 6 links activities to resources and the resources to costs. Table 7 provides the calculation of the unit cost of each activity. For example, the average cost of assembling components is $40,000 divided by 1.3 million, or $0.0308 each. Table 8 shows the unit cost of producing each component. For example, the unit cost of producing a gadget is $0.4073. Table 9 allows a comparison of unit costs as calculated using ABC with unit costs as figured using traditional cost accounting rules.

Table 5. Costs of products as related to activities.

	Cost Drivers		
Products	**Assembly**	**Inspection**	**Material Handling**
Gadgets	4	7	4 X 250/50 = 20
Widgets	6	2	6 X 40/50 = 4.8

Table 6. Activities related to resources and costs.

Activities	Total Hrs/yr	Cost/hr	Cost/yr
Assembly	2 x 40 x 50 = 4000	$10.00	$40,000
Inspection	2 x 40 x 50 x 70% = 2800	$10.00	$28,000
Material Handling	2 x 40 x 50 x 30% = 1200	$10.00	$12,000

Table 7. Determining the unit cost of activities.

Activities	Cost/yr	No. of Drivers	Cost Per Driver
Assembly	$40,000	1.3 million components	$.0308/component
Inspection	$28,000	1.0 million tests	$.0280/test
Material handling	$12,000	2.72 million feet	$.0044/foot

Table 8. Calculating the unit cost of production via ABC.

	Assembly		Inspection		Material Handling		ABC Unit Cost
Product	No.	Cost	No.	Cost	No.	Cost	$0.4073
Gadget	4	$0.0308	7	$.0280	20	$0.0044	$0.2618
Widget	6	$0.0308	2	$.0280	4.8	$0.0044	$0.2618

Table 9. Calculating unit costs of production using conventional cost accounting.

Product	Total Direct Labor Costs	% of Direct Costs	Overhead Allocation	Total Production Costs	Conventional Unit Costs	% Error in Unit Costs
Gadgets	$ 12,300	30.75%	$ 12,300	$ 24,600	$.2460	-39.6%
Widgets	$ 27,700	69.25%	$ 27,700	$ 55,400	$.3693	+41.1%
Totals	$ 40,000	100%	$ 40,000	$ 80,000		

In the latter case, the assembly costs of gadgets and widgets are viewed as direct costs; the inspection and material handling costs are treated as indirect. The indirect costs would be allocated to gadgets and widgets in proportion to the direct costs of each product. The amounts that would result from the conventional cost accounting approach are calculated in Table 9. Note that the last column indicates traditional cost accounting and yields an error of approximately 40 percent in allocating the unit costs of the two products.

ABC has been applied to the service industry in an effort to give managers a framework for making sound business decisions by identifying all the costs associated with providing a particular service. Using ABC, organizations can more clearly see the true costs of products and services. Organizations can use this information to make decisions that improve the profitability of their operations. ABC can be applied to the cost justification of a performance support environment in certain specific situations. The ABC approach can be useful in production offices and in structured knowledge work environments where tasks are essentially repetitive.

Consider a production office where the primary work requirement involves repetitively performing certain processes, such as preparing reports, preparing budgets, and collecting data from other personnel. The tasks may be repeated on a daily, weekly, monthly, yearly, or other periodic basis.

Each process is initiated by a specific driver, such as a request from management, the approach of the due date for a weekly report, a data call, or appointment to a committee. Each process is composed of tasks, such as entering data into a spreadsheet, sending email messages, attending meetings, preparing documents, scheduling meetings, or making phone calls. For example, Table 10 shows the application of the ABC technique to the preparation of a weekly report that indicates how 60 knowledge workers charged their time to projects.

The ABC breakdown of processes, tasks, and costs provides information that would be useful both in building the database of processes and in selecting PIPs. However, the cost of the tasks that comprise each process is difficult and expensive to assess. A

Table 10. ABC applied to knowledge work task.

Element	Example
Driver	Weekly requirement to report division's staff hours (by project) for labor accounting system
Task	Prepare Labor & Time Sheet for 60 knowledge workers
Activities	1. Send email request for report of time spent on each project for weekly reporting period. 2. Collect delinquent reports. 3. Check all reports for accuracy & completeness. 4. Contact individuals with inaccurate or incomplete reports. 5. Enter data from scrubbed reports into system.
Time spent on task (per week)	Activity 1: 0.10 hour Activity 2: 0.40 hour Activity 3: 1.10 hour Activity 4: 0.30 hour Activity 5: 0.60 hour Total: 2.50 hours per week
Implicit cost of task (per year)	$ 12.95 * 130 = $ 1,683.50 labor cost X total No. of hours = annual cost

manual or automated time logging instrument could be constructed to help gather the implicit costs of each task.

The time and expense of collecting this information, however, is probably not warranted unless the workgroup being analyzed is both structured and stable, i.e., if the tasks are always done using the same procedures, and if the processes are not likely to be changed for several months. If these conditions are not met, the resources necessary to implement ABC are likely to be greater than the benefit gained.

ABC is also recommended as an evaluation technique in those cases where both Integrated Definition (IDEF) process modeling and ABC have been performed as part of other initiatives. The Department of Defense (DOD) has recommended the use of both IDEF and ABC as part Functional Process Improvement efforts in the Defense Information Management Program (1993).

If ABC has been implemented for workgroups where a performance support environment (PSE) is being introduced, the results can be used to identify the processes that consume the largest amount of labor resources. The most costly processes should be examined as likely PIPs, as mentioned previously. These same processes may warrant further data collection after the PSE has been fully implemented. This post-implementation data can be done using either another technique such as Work Profile Analysis or Time Saved Times Salary, or by re-application of ABC.

Quality Assessment

Improved quality, along with enhanced employee performance, is a key benefit acclaimed by performance support systems (Gery 1991). Along with any performance impacts an organization tracks, changes in quality should also be monitored. The desire for improved quality is one of the top six reasons that organizations invest in information technology, where the top six reasons for investing in information technology are to:

1. Improve infrastructure for communications and data handling
2. Meet mandated requirements
3. Reduce costs
4. Provide new products
5. Improve quality
6. Facilitate major strategic repositioning.

Paradoxically, organizations report difficulty in measuring the impact of IT on quality. Further, the impact of the technology investment is largely meaningless without a valid metric of the quality of the resulting output (National Research Council 1994).

Service-oriented organizations have provided leadership in developing tools and methods that track customer-oriented measures of quality. These tools were developed in response to the strong positive correlation between costs and the quality of service. Reduction of errors in producing a service reduces both coordination costs and rework, as well as customer complaints.

Organizations implementing a PSE are encouraged to develop and use customer-oriented quality metrics for similar reasons. The tools used by private sector service organizations are largely applicable for use within government environments. For example, some methods used by service organizations are: focus groups, user groups, quality circles, process action teams, pilot tests, surveys, sampling, interviews, observation, and other quality management tools (Deming 1986). Each of these may be useful in assessing quality within a specific setting.

Minimally, methods should: (1) collect customer feedback, (2) collect supervisory feedback, and (3) provide opportunities for self-assessment. This information can be collected fairly inexpensively, using methods such as interviews, surveys, and/or tools built into the system itself.

For example, KWS will use surveys and on-line tools to collect quality-related data. Customers of KWS users will be surveyed to ascertain their level of satisfaction with the timeliness, completeness, and general quality of the products generated using KWS. KWS users will be surveyed via periodic electronic mail surveys about their own productivity. Supervisors of KWS users will likewise be surveyed to assess the productivity and quality of work performed by their subordinates who use the system. Finally, KWS users will have the capability to summon an on-line tool that allows comments on the usefulness of specific KWS features.

The information collected will be used to: (1) assess the perceived quality of the work performed by KWS users, and (2) gather information on the perceived usefulness of system functionality. The first category of information will be collected prior to and following KWS implementation.

Tools for collecting data about quality issues have been thoroughly detailed in the Total Quality Management (TQM) literature (Brassard 1988, Deming 1986, Cleary 1993). Figure 4 lists several tools described in TQM literature. The tools are grouped

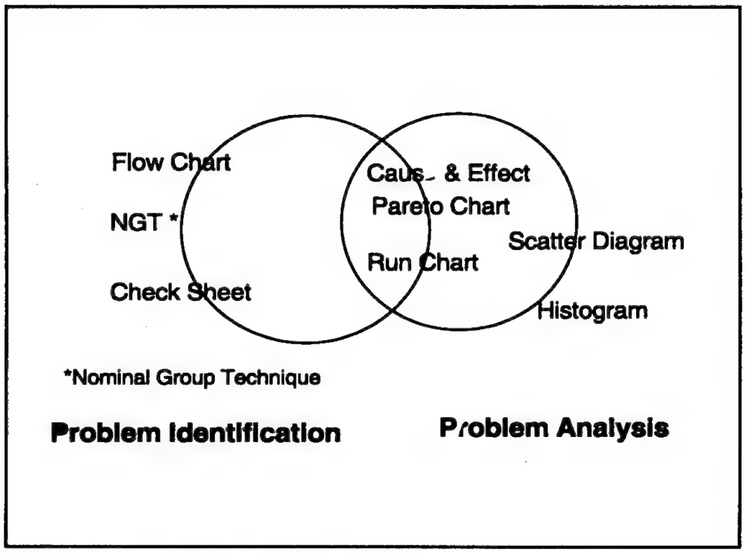


Figure 4. Tools for quality assessment.

into "problem identification" or "problem analysis" categories. Several tools are useful for both types of problem solving.

Organizations implementing a PSE are encouraged to assess quality along with the particular performance measures they choose to track. Quality-related data from customers, PSE users, and from supervisors of PSE personnel can provide important feedback about the strengths and weaknesses of the PSE. Table 11 summarizes the PSE evaluation techniques, the environments where they might best be applied, and the advantages, disadvantages, and relative cost of each technique.

Table 11. PSE evaluation techniques.

Technique	Recommended Environment	Pro	Con	Cost*
Work Profile Analysis	All	Complements PSE purpose; Can be automated	Data intensive; Time consuming	Low-med
Direct vs Indirect	Production Office KW **	Intuitive; Identifies tangential activities	Data intensive; Time consuming	Low-med
TSTS	All	Easy to implement Intuitive; Attractive to management	May measure the wrong attribute	Low
ABC	Production Office KW **	Identifies costs	Data intensive; Time consuming	Med-high
Workflow	Production Office	Systematic; Good analysis tool	Time consuming	Med-high
Quality	All	By definition, measures what's important	Can be time consuming	Low-med

* Costs can be reduced if initial information is collected as part of process building performed by the PSE implementation team.

** Also appropriate in knowledge work environments where processes are stable and structured. Note that many DOD organizations have performed ABC as part of other process modeling initiatives.

5 Conclusion and Recommendations

A broad review of relevant literature shows that no single tool can effectively measure and evaluate an activity as complex and intangible as knowledge work, or a performance support environment (PSE) for knowledge workers. This study concludes that a “toolkit” of five evaluation techniques, each applicable to a specific workgroup setting, may best assess the feasibility and usefulness of a PSE:

1. Work Profile Analysis
2. Direct to Indirect Ratio
3. Time Saved Times Salary (TSTS)
4. Activity Based Costing (ABC)
5. Quality Assessment.

The first step in selecting the appropriate tools for evaluation is to categorize the type of knowledge work performed within the environment. The potential PSE site should be analyzed for four composite attributes: (1) complexity, (2) volume per job, (3) time per job, and (4) repetition.

A workgroup should first be categorized as either a knowledge work-intensive (KW) professional environment, or a production office. A professional office is one whose primary function requires professional level workers, where the work is not substantially repetitive, and where the clerical work is performed in support of professional work. A production office is an office whose primary function is the performance of a small number of repetitive, clerical-level tasks, e.g., claims processing, order entry, and call centers.

Once the workgroup is categorized, an appropriate evaluation tool should be selected. The Information Economics (IE) cost-benefit analysis is recommended as the first step in deciding which PSE impacts to evaluate. It is also recommended that a quality assessment be done in conjunction with any other evaluation tool.

References

Cited

Anthony, G. Michael, "IE's Measure Work, Write Standards for White Collar Workers at Financial Institution," *Issues in White Collar Productivity* (Industrial Engineering and Management Press, Institute of Industrial Engineers, 1984), pp 84-87.

Bernard, Paul, "Structured Project Methodology Provides Support for Informed Business Decisions," *IE* (March 1986), pp 52-57.

Beruvides, M.G., and D.J. Sumanth, "Knowledge Work: A Conceptual Analysis and Structure," *Productivity Management Frontiers—I* (Elsevier Science Publishers B.V., 1987), pp 127-138.

Brassard, Michael, *The Memory Jogger—A Pocket Guide of Tools for Continuous Improvement* (Goal/QPC, 1988).

Cleary, B.A., "Company Cares About Customers' Calls," *Quality Progress*, vol 26, No. 11 (November 1993), pp 69-73.

Cox, Thomas, "The Myth of the Commodity Database or How To Pick the Best Technology for You," *Oracle Integrator* (January/February 1993), pp 19-21.

Drucker, Peter F., *Management* (Harper & Row, 1974).

Helton, B. Ray, "Achieving White-Collar Whitewater Performance by Organizational Alignment," *National Productivity Review* (Spring 1991), pp 227-244.

Helton, B. Ray, "Quality and the Bottom Line, Part 2: The Company's Side," *The Quarterly Observer* (March 1992), p 5.

Helton, B. Ray, "Quality and the Bottom Line, Part 3: The Inner View," *The Quarterly Observer* (April 1992), p 3.

Helton, B. Ray, "More of the Right Stuff," *The Quarterly Observer* (September 1993), p 5.

Liggettt, Trevino, and Lavelle, "Activity-Based Cost Management Systems in Advanced Manufacturing Environments," in Parsaei et al. (eds.), *Economic and Financial Justification of Advanced Manufacturing Technologies* (Elsevier, Amsterdam, 1992).

National Research Council, *Information Technology in the Service Society* (National Academy Press, Washington, DC, 1994).

Parker, Marilyn M., Robert J. Benson, and H.E. Trainor, *Information Economics Linking Business Performance to Information Technology* (Prentice-Hall, Englewood Cliffs, NJ, 1988).

Peterson, I., Probing a Computer Productivity Paradox," *Science News* (1 Jan 1994), p 7.

Rittenhouse, Robert G. "Productivity and the Microcomputer," *Management of Technology III* (Institute of Industrial Engineers, 1992).

Roach, Stephen, "Services Under Siege—The Restructuring Imperative," *Harvard Business Review* (September-October 1991), pp 82-83.

Sassone, Peter G., "Cost Benefit Methodology for Office Systems," *ACM Transactions on Office Information Systems*, vol 5, No. 3 (July 1987).

Sassone, Peter G.. "A Survey of Cost-Benefit Methodologies for Information Systems," *Project Appraisal*, vol 3, No. 2 (June 1988), pp 73-84.

Sassone, Peter G., "Office Productivity: The Impacts of Staffing, Intellectual Specialization and Technology" (The Georgia Institute of Technology—School of Economics, September 1991), pp 1-35.

Sassone, Peter G., "Three Approaches for Estimating the Value of Office Work," *Office Technology and People*, vol 6, No. 1 (1992).

Sassone, Peter G., "Survey Finds Low Office Productivity Linked to Staffing Imbalances," *National Productivity Review* (Spring 1992), pp 147-158.

Thomas, B.E., and J.P. Baron, *Evaluating Knowledge Worker Productivity: Literature Review*, Interim Report (IR) FF-94/27 (U.S. Army Construction Engineering Research Laboratories [USACERL], June 1994).

Uncited

Johnson, H. Thomas, "It's Time to Stop Overselling Activity-Based Concepts," *Management Accounting* (September 1992), pp 26-35.

Kelly, Robert, and Janet Kaplan, "How Bell Labs Creates Star Performers," *Harvard Business Review* (July-August 1993), pp 128-139.

Partovi, "An Analytic Hierarchy Approach to Activity Based Costing," *International Journal of Production Economics*, vol 22 (1991), pp 151-161.

Appendix A: Taxonomy of KWS Benefits and Capabilities

KWS Implementation Scoresheet

The following Scoresheet (Figure A1) is divided into four blocks to facilitate the discussion of how to complete and utilize it. Each block has a specific function that is detailed in Figures A2 to A5.

BLOCK 1 The value codes appropriate to each evaluation class are entered in the "value code" column. The value codes are detailed in block 4. For example, if improving performance is important to you, enter a "4" in the code column next to that class (Figure A2).

BLOCK 2 Each benefit category is related to each value class by entering the appropriate relation code in the corresponding columns. The relation codes are detailed in block 4. For example, if you determine that reduced rework is strongly related to Performance Improvements, enter a "4" in the #2-value-column of that category [B] (Figure A3). The "Ind Benefit Scores" column on the right side of block 4, is where the sum of the products for each category is entered. Figure 3 shows an example where a "16" is entered—a value of 4 times a relation of 4. Figure 4 shows a more complete example.

BLOCK 3 The sum of the individual scores from block 2 is entered in the space to the right of "SCORE FOR KWS IMPLEMENTATION" (Figure 5).

BLOCK 4 The codes used to rate value classes and benefit categories are explained in this block. These are not hard quanitiative values, but are "fuzzy" values, i.e., your interpretation of the values and benefits of these items to the process being examined. The definitions given are, therfore, purposely ambiguous so that they can be applied to any situation.

BLOCK 1

VALUE CLASSES			
	Value Code	Value #	Name
Importance of the value to the organization		1	ENHANCED ROI
		2	PERFORMANCE IMPROVEMENTS
		3	STRATEGIC MATCH
		4	STRATEGIC IS ARCHITECTURE
		5	
		6	

BLOCK 2

KWS BENEFITS

Relation to numbered value 1	2	3	4	5	6	Benefit Ltr.	Name	Ind Benefit Scores
						A	Improved Effectiveness	0
						B	Reduced Rework	0
						C	Improved Efficiency	0
						D	Improved Focus	0
						E	Work Elimination	0
						F		0
						G		0
						H		0
						I		0
						J		0
						K		0
						L		0

BLOCK 3

SCORE FOR KWS IMPLEMENTATION **0**

BLOCK 4

EXPLANATIONS OF CODES

Relation Codes		Value Codes	
0	No Relation	0	Not Relevant
1	Minimal Relation	1	Not Important
2	Some Relation	2	Little Importance
3	Moderate Relation	3	Moderate Importance
4	Strong Relation	4	Important
5	Absolute Relation	5	Very Important

Figure A1. Scoresheet for KWS implementation.

BLOCK 1

VALUE CLASSES			
	Value Code	Value #	Name
Importance of the value to the organization		1	ENHANCED ROI
	4	2	PERFORMANCE IMPROVEMENTS
		3	STRATEGIC MATCH
		4	STRATEGIC IS ARCHITECTURE
		5	
		6	

Figure A2. First block of KWS implementation scorecard.

BLOCK 2

KWS BENEFITS								
Relation to numbered value						Benefit		Ind Benefit Scores
1	2	3	4	5	6	Ltr.	Name	
						A	Improved Effectiveness	0
						B	Reduced Rework	0
						C	Improved Efficiency	0
						D	Improved Focus	0
						E	Work Elimination	0
						F		0
						G		0
						H		0
						I		0
						J		0
						K		0
						L		0

Figure A3. Sample block containing "Indicate Benefit Scores" column.

BLOCK 1

VALUE CLASSES

	Value Code	Value #	Name
Importance of the value to the organization	3	1	ENHANCED ROI
	4	2	PERFORMANCE IMPROVEMENTS
	1	3	STRATEGIC MATCH
	2	4	STRATEGIC IS ARCHITECTURE
		5	
		6	

BLOCK 2

KWS BENEFITS

Relation to numbered value 1	2	3	4	5	6	Benefit Ltr.	Name	Ind Benefit Scores
						A	Improved Effectiveness	0
5	4	0	1			B	Reduced Rework	33
						C	Improved Efficiency	0
						D	Improved Focus	0
						E	Work Elimination	0
						F		0
						G		0
						H		0
						I		0
						J		0
						K		0
						L		0

Figure A4. Sample benefit score entry.

BLOCK 2

KWS BENEFITS								
Relation to numbered value						Benefit		Ind Benefit Scores
1	2	3	4	5	6	Ltr.	Name	
4	4	0	0			A	Improved Effectiveness	28
5	4	0	1			B	Reduced Rework	33
4	4	0	0			C	Improved Efficiency	28
5	5	3	0			D	Improved Focus	39
5	5	2	0			E	Work Elimination	38
						F		0
						G		0
						H		0
						I		0
						J		0
						K		0
						L		0

BLOCK 3

SCORE FOR KWS IMPLEMENTATION 166

Figure A5. Sample completed benefit scores.

Primary Objectives

The primary objectives of the Knowledge Worker System are:

- Enhanced Knowledge Worker Performance
- Improved Quality.

Benefit I. Effectiveness Improvements

This benefit encompasses the capabilities described in benefits II - V.

Benefit II. Rework Reductions

Capability: Process Model Documented

a. Describes work procedures in detail
b. Disseminates changes in process to all players

c. Facilitates delegation of portions of process
d. Provides clear specification of assignments

Capability: Institutional Knowledge Captured

a. Records experience/tips/lessons learned of previous job occupants
b. Trains new employees
c. Facilitates job rotation

Benefit III. Efficiency Improvements

Capability: Shared Task Schedule

a. Identifies task priorities
b. Monitors task status
c. Automates resource leveling
d. Provides early notification of deadlines
e. Updates schedule changes
f. Allows what-if analysis of schedule
g. Provides coordination between workgroup members
h. Monitors delegated tasks

Benefit IV. Focus Improvements

Capability: Referential Information Linked to Tasks

a. Reduces time spent accessing references
b. Provides examples of previous submissions
c. Frees time for analysis/decisionmaking
d. Allows referential information to be shared

Benefit V. Work Elimination

Capability: Tasks Automated & Linked to Tasks

a. Reduces time spent on repetitive tasks
b. Reduces time spent on accessing external software/systems/databases
c. Allows automation tools to be shared

Appendix B: An Analysis of the Techniques and Application of Information Economics to KWS

Introduction

Information economics (IE) is an effort to provide a more complete means, when compared to simple return on investment (ROI), of evaluating potential projects for a company. IE is a form of decisionmaking and therefore, the evaluation technique is not limited to evaluating projects, but can be used in many decisionmaking situations. The application of this technique to evaluating potential implementation sites for the Knowledge Worker System (KWS) would be very useful. IE could provide an excellent approach of determining which performance trends to track for that KWS pilot site. The following text is an analysis of the techniques used in Information Economics and its extension to KWS.

Analysis of IE

Background

A typical comparison of possible projects is based on accounting type of information, i.e., projected costs, projected benefits, and return on investment. The comparison may involve several projects competing for resources or it may simply be a single project competing with the current situation. The problem with all of this is that it ignores a number of factors that may effect the success of the project(s) simply because these factors do not lend themselves to dollar quantification. IE provides a methodology for including nonquantifiable factors in the analysis of projects. (For a detailed presentation see Parker, Benson, Trainor 1988.)

It is important to note that IE attempts to make explicit some of the biases implicitly applied in evaluating alternative projects. For example, the organization's aversion to risk may be recognized as a factor in rating projects. Different organizations may come to different conclusions when evaluating the same project.

The most important factors in evaluating projects are recognized and given relative weights. A firm very interested in ROI may use a weight of 10 versus a weight of 2 for competitive response. Then each project is ranked for each factor. In the case of ROI and other quantitative measures, actual numbers can be applied. The weights for each factor are applied to each project's rankings for the factors and a total score is determined. A comparison of these scores can give a good picture of the project(s) that are best suited to this organization's vision.

The application of IE can be observed in a "tool" developed by Oracle Corp. called CB-90 - Cost Benefit for the Nineties. CB-90 breaks the analysis down into three factors: Tangible cost/benefit analysis, Intangible cost/benefit analysis, and Intangible risk analysis (Semich 1994). The latter two can be further subdivided into business and technical groupings (Cox 1993). These two articles with another (Pastore 1992) provide a valuable insight into the application of the IE theory.

The IE Methodology

Information Economics focuses on value rather than the more limited concept of benefit. It should be noted that much of the terminology used in IE represents an application to the nongovernmental organization. This does not decrease its applicability to governmental structures. It simply means that some adjustments will be required. IE uses six classes of value summarized as follows:

1. *Enhanced ROI* — Like a standard return on investment but expanded to include additional methods: value acceleration, value linking, value restructuring, and innovation valuation.

2. *Strategic Match* — This is a measure of how closely aligned the project is to the organization's strategic goals.

3. *Competitive Advantage* — Estimates the degree to which the project provides an advantage in the marketplace. This can be viewed as an improvement in the product or service of the organization or of a sharpening of the focus of its vision.

4. *Management Information* — Management needs information. The value of the information, or the improved information, that the project is expected to provide is the factor here. The more essential to the functioning of the organization that the project's information is the more valuable it may be.

5. *Competitive Response* — This is an estimate of the consequences of not implementing the project. This can be viewed as the nonmarketing consequences of inactivity. An organization that appears unable to handle its work effectively may no longer have that work to do or it may find itself reorganized into some other organization.

6. *Strategic IS Architecture* — The implicit assumption in this value is that there is some strategic plan for the information systems of the organization. The measure here is of how the project fits into and/or complements that overall plan. In the absence of a plan it may be measured as to how well it lays the groundwork for such a plan.

Each of these value classes is assigned a weight for the organization in which the IE analysis is occurring. Eventually every proposed project will be evaluated in each value class for its effect and then a summarized score is calculated for each project.

IE applied to KWS

Background

Typically, with IE, an organization starts with a vision and proceeds to establish the criteria and their weights to be used in deciding which projects best fit into its vision. In applying IE to KWS we must start with a set of potential benefits attributable to KWS and then set up a methodology for evaluation in differing environments. The following illustration clarifies this difference.

> PERFECT Company places great value on never making a mistake on a customer's order. Their vision is focused on this error free goal. Their evaluation of any project will weight heavily its affect on perfection. CHEAP Company on the other hand takes great pride in being the cheapest price on the market and naturally will weight any project heavily for its affect on price. The typical IE evaluation would take place in the environment of the subject company and would have criteria and weights established based on the vision of that company. The approach we must make in evaluating KWS is to develop a set of criteria in a tool such that the vision of the implementation prospect can be accounted for.

In applying information economics methodology to KWS implementation it is important to remember that IE is used to estimate the value of a choice to an organization. If IE allows you to estimate this value before the event, then it can also be applied to estimating the value of the decision after the event. As the majority of

the work will have been accomplished in the initial estimate, the work involved in the second estimate will be greatly reduced.

The specific means of evaluating the selected criteria is a separate decision. The IE process establishes what is deemed important by the user. The appropriate measures and tools can then be selected.

Consider the example mentioned above. The PERFECT Company's overriding concern is perfection. Therefore, it will want to evaluate the level of perfection achieved after the decision is made, that is, if it were to use IE in the same manner suggested here.

Suppose that one of the benefits of KWS is that it makes the scheduling more efficient, and that one member of the implementation team has rated this as a very important benefit. Part of the determination of the KWS productivity for this implementor would be the improvement of scheduling. Other factors would also have to be included in this evaluation of productivity, but one measure that must be taken is the change in the scheduling function.

One of the important points of this technique is that the productivity change is based on the factors important to the user. If the cost of the change is of relatively low importance to the user, this can be accounted for in this technique. Likewise, the technique can account for the user for whom the costs are very important. It could be argued that two users in similar circumstances might then produce widely different productivity changes. The real measure of the productivity change is what the user perceives and if the user has established a vision then this perception should be the best measure of utility.

It is important to note that this technique ties the measure of productivity to the implementor's vision. This vision should reflect a concern about the "customer," for as Peter Drucker (1974) noted, the purpose of an enterprise is to create a customer.

An Outline of the Technique

To use IE techniques to evaluate a specific project—the implementation of KWS—we must first establish the benefits of KWS. The following section discusses a set of potential benefits.

Our list of benefits is something we take to each potential implementation site. At each site we must then establish the values of the organization. This second step allows us to plug these figures into a worksheet and produce a rating for the

implementation of KWS at that site. As there is no alternative project(s) to compare KWS to simply compare it to the status quo. Of course, if KWS is implemented, we will later compare the post-implementation and the pre-implementation scores to establish the productivity change. The score for the status quo, however, is not necessarily zero, although it could be. The status quo may have a very negative score (in those situations where collapse is imminent). It could have a significantly positive score—in those situations where operations are running well. The comparison would indicate situations where the impact of KWS would be significant and minor.

The evaluation tool then starts with a group of established benefits. The second step is to determine the weights to be applied to the six values of IE and to score the KWS benefits for the organization. This process must be done by the organization itself.

The Benefits of KWS

The benefits of KWS can be organized in many different ways. One approach is to separate the benefits into three broad categories:

1. *Knowledge Oriented Benefits* – An assortment of tools, data, and resources that are used in the performance of work. In reference to KWS the access to these is automated and therefore their utilization is both more efficient and effective.

2. *Control Oriented Benefits* – Those aspects of KWS that allow both the individual and management to be aware of the status of work and to respond in a timely manner to that status.

3. *Action Oriented Benefits* – When work is actually performed, there may be many repetitive tasks that occupy significant portions of the performer's time. Automating or organizing these tasks via KWS has a benefit in excess of stand alone improvement.

Knowledge

- **Reduce external references for how-to-do-it information**
  How-to-do-it information will exist on the system. Formal rules and manuals will be accessible along with learned-on-the-job information. Both new and experienced workers will be able to perform complex tasks with less references to external sources.

- **Examples automatically available**
  Files and data associated with particular tasks will be accessible via KWS. This means that previous examples of a task will be easily available for reference and that the processes currently being utilized will be accessible. This reduces the time spent looking for information and it increases the accuracy of the work performed.

- **Related information will automatically be accessible**
  Information associated with a task will be kept associated with that task. This reduces the time spent looking for missing information.

- **Procedural knowledge will automatically updated**
  Procedures will be easier to document. The procedures can grow from the actual work being performed.

Control

- **Priorities will be updated automatically**
  Individuals will be able to see what their priorities are for the day, week, and further into the future. They will therefore be able to concentrate on the higher priority items.

- **Prior work will be referenced via the system**
  Individuals will be able to see what they've done in the past.

- **Managers can optimize for changing situations**
  Managers can optimize the abilities of the people available by reassigning work and or priorities as situations change.

- **Scheduling will be automated**
  Annual leave, training, and other such activities can be scheduled in less time and more effectively.

- **The ability to function as a group is enhanced**
  Individuals can perform as members of the group by accessing schedule and other information and then acting on it.

Action

- **Repetition will be reduced**
  Repetitive tasks will be automated reducing the amount of time necessary to prepare reports, write memos, gather data, etc.

- **The software maze will be eliminated**
  All actions will be do-able from KWS. This reduces the time and complexity of moving from software environment to software environment.

- **Access to other equipment will be simplified**
  The KWS environment will reduce the time and effort involved in accessing equipment, data and facilities.

An IE Toolset for KWS

Applying IE methodology to the implementation of KWS is not a simple process —you can't simply pick one from column A, one from column B, and so on. However, it doesn't need to be a difficult process either. The use of a "Toolset" is what reduces the difficulty of the process. We understand the workflow by using a structured interviewing process. A layered survey gains the value information we need and a spreadsheet calculates the productivity value we are looking for. The first tool, the structured interviewing process, has already been referenced. The second and third tools will be discussed below.

We must elaborate on the values that the organization has and apply them to the KWS application benefits. We would conduct a survey, or rather a layered survey, where we first seek to establish a consensus on the general vision of the organization. From there we then proceed to the next layer and establish consensus on the weights the organization would apply to the various value classes. The third layer would entail a detailing of the value classes and weighing each of them. From this information, we would be able to transfer the weights to a spreadsheet that would be linked to the KWS benefits. A fourth layer would be to estimate the potential for each KWS benefit. Some benefits depend for their relevance on the organization's environment. For example, if the reduction in the access to external references is one of the KWS benefits, but the subject organization never does this, there is no potential to this benefit in this environment. Once this information has been established and entered to the spreadsheet, it would automatically produce a score for the implementation of KWS in the organization. Important to this process is getting an estimate from the

organization of how well it feels it currently performs or satisfies each of the values. This would produce the current rating to compare with the KWS rating.

Summary

This approach to evaluating the benefits of KWS in a particular environment has a very broad range of application. It can be done very simply in a very short time and yet produce a good evaluation. It can also be done in a more complete manner to produce more detailed and better evaluations. As such, the amount of effort invested in the evaluation need not determine the applicability of the results. The quality of the effort is much more important. This emphasis is quite different from many evaluation techniques where the quantity of effort is the controlling factor.

The participation of the members of the area being studied is crucial with the IE approach. Taken farther these individuals could, with some assistance, conduct the studies themselves. Reaching concensus among study participants is a significant by-product of the IE process.

For further reading on Information Engineering:

Parker, Marilyn M., Robert J. Benson, and H.E. Trainor, *Information Economics: Linking Business Performance to Information Technology* (Prentice-Hall, Englewood Cliffs, NJ, 1988).

Drucker, Peter F., *Management* (Harper & Row, 1974).

Semich, William J., "Here's How To Quantify IT Investment Benefits," *Datamation*, vol 40, No. 1 (7 January 1994), pp 45-48.

Cox, Thomas, "The Myth of the Commodity Database or How To Pick the Best Technology for You," *Oracle Integrator* (January/February 1993), pp 19-21.

Pastore, Richard, "Many Happy Returns," *CIO*, No. 5 (15 June 1992), pp 66.

Appendix C: Time Logging Introduction and Instructions for Knowledge Workers

Introduction

A select group of HQUSACE managers and professionals has been cooperating with USACERL in the initial development of the Knowledge Worker System, a PC- and LAN-based computer application for supporting and automating some of their administrative tasks. The members of the initial KWS user group are key players in the PPBES cycle.

Because the development, implementation and possible future extensions of KWS absorb scarce Army resources, it is important that KWS be cost justified. This involves identifying and measuring the various benefits and costs associated with the system. The best approach to doing this is to begin with a baseline work analysis (to document work patterns prior to implementing KWS), and then to analyze work patterns after KWS has been implemented. A comparison of these two work pattern snapshots will serve as the basis for identifying and quantifying the impact of the system.

The economic benefits of knowledge work frequently are difficult to quantify because most knowledge work is complex in content and impact. However, a new approach for measuring the impact of productivity interventions (such as KWS) on knowledge work has been developed and used successfully in several dozen recent private sector studies. This new methodology is called Work Profile Analysis. It is based on the simple but powerful concept of the "intellectual content" of work.

In general, organizations pay their employees based on the intellectual content of the work that they are capable of performing. Engineers with advanced training and much experience are paid more than new and inexperienced engineers. An engineer with management training, ability and experience is paid more than an engineer without those qualifications. Similarly, program and budget analysts with more training and experience are paid more than those with less. And of course, analysts and engineers are paid more than secretaries and clerks.

At the same time, workers do not spend 100 percent of their work time doing the work that their training and experience qualifies them to do. For example, managers,

engineers and analysts may spend only a fraction of their time in work that could, in principle, be delegated to lesser skilled and lesser paid employees. Indeed, research has shown that pattern to be the norm rather than the exception. Of course, in many organizations, it is the shortage of workers to whom work may be delegated that is responsible for this pattern of work. For example, and quite simply, there often are not enough secretaries and clerks in an office to handle all the secretarial and clerical tasks, and therefore many of those tasks must be done by professionals and managers.

By analyzing how workers at each position in an organizational hierarchy typically spend their time (in terms of the intellectual content of the work that they are doing), and by factoring into the analysis the typical number of hours worked and the total cost (wages or salary, overtime, fringe benefits) of those workers, the actual (implicit) cost of different types of work (management work, engineering work, analysis work, secretarial work, ...) in that organization can be calculated.

As a simple example of this methodology, suppose workers in an engineering organization typically spend their time as shown in Table C1. For simplicity, assume that everyone works 40 hours per week for 46 weeks per year (this assumes 6 weeks total of vacation, holidays, sick days and training days per employee). Finally, suppose that the average annual total cost (salary or wages plus fringe benefits) to the organization of a person in each position is given in the last column of the table.

Example Work Profile Matrix

With these assumptions, the implicit cost to the organization of management level work is $76.49 per hour, of professional engineering is $51.33 per hour, and of administrative support work is $18.12 per hour. (Determining these values involves a mathematical economic model. You can check the figures by noting that the values uniquely and exactly account for the average salary in each position.) To check these values for managers, note that managers spend 552 hours per year doing management level work (46 weeks x 40 hours/week x 30%), 736 hours per year doing engineering work (46 weeks x 40 hours/week x 40%), 276 hours per year doing support work

Table C1. Sample work profile matrix.

	Management Work	Professional Engineering Work	Administrative Support Work	Nonproductive Work	Average Annual Cost
Managers	30%	40%	15%	15%	$85,000
Engineers	0%	60%	25%	15%	$65,000
Secretaries	0%	0%	90%	10%	$30,000

(46 weeks x 40 hours/week x 15%), and 276 hours per year in nonproductive work (46 weeks x 40 hours/week x 15%). Then note that : (552 hours of management x \$76.49/hour) + (736 hours of engineering x \$51.33/hour) + (276 hours of support work x \$18.12/hour) + (276 hours of nonproductive time x \$0.00/hour) = \$85,000. Similar checks can be made for the engineers and secretaries in our example.

These implicit costs can be used to estimate the value of a computer system, such as KWS. Continuing the simple illustrative example, suppose that KWS could absorb 60 percent of the administrative support work and 33.3 percent of the nonproductive work done by engineers, and suppose that the saved time is redirected into professional engineering work. The new row in the work profile matrix would be:

Engineers	0%	80%	10%	10%	\$65,000

The value to the organization of this shift in the engineers' work profile would be \$18,889.44 per engineer per year (20% x 40 x 46 = 368 additional hours of engineering work per engineer per year @ \$51.33 per hour.) This calculation assumes that the additional engineering time is productive. That is, it assumes that there is a continuing "backlog" of engineering work to do, and that this additional engineering work is as worthwhile as the other engineering work.

In reality, of course, actual cases are far more complex than the example described above. Nonetheless, these same ideas, incorporated in more complex models, can be (and have been) successfully used to evaluate virtually any productivity intervention in a knowledge work environment.

This Study

The information needed for this study is "time log" data, that is, data on how everyone spends their time. We will use this data to develop a productivity snapshot of several USACE Headquarters offices. The data collection and analysis is based on two critical assumptions:

1. That individuals are experts in their own areas of work, that they are currently doing their jobs as well as possible, but that their performance may be limited or impeded by factors such as the type and amount of technological support that they have available, by various established policies and procedures, by the performance of other government organizations, or by an incorrect level of staffing.

2. That the data that we collect on any one individual is not necessarily representative of how that individual typically spends his or her time. Only by combining the data for all persons in a certain position (e.g., engineer or analyst) will a statistically significant work profile emerge.

To complete the study, we need your cooperation in completing time logs. We ask that you make your entries on your time log sheet once each hour for your assigned three consecutive work days.

So that we get an accurate picture of the work in your organization, it is important that you conscientiously complete the time logs. After reading these instructions and completing your first entries will take only a minute or two.

Categories of Work in the USACE Headquarters

There are six major broad types of work in the organization, along with several important finer distinctions. The six major work categories are:

1. Managerial and supervisory tasks
2. Professional engineering tasks
3. Program and budget analysis tasks
4. Technical support tasks
5. Administrative tasks
6. Tasks related to work on government committees.

Each of these categories of tasks is explained in detail in "Appendix D: Dictionary of Work Categories and Example Tasks." In addition to these six major categories of tasks, there are several other activities which normally occupy the time of HQUSACE personnel. These are: professional development, nonproductive time, community service, travel, and personal time.

Finally, for these few days, completing the time log is an activity which will take a few minutes of each hour. These activities are explained in the same document. Tasks usually are composed of distinct sub-tasks. For example, the task of preparing an engineering analysis might include the following sub-tasks:

1. Identify and access the appropriate procedures
2. Read and understand the procedures
3. Gather the necessary data and information
4. Review the data and information for completeness

5. Locate and access additional information if needed
6. Perform the required engineering analysis
7. Prepare a draft report of findings and conclusions
8. Discuss analysis, findings, and conclusions with supervisor
9. Prepare the final report, including tables and graphics
10. Make copies of the report for distribution
11. Forward the copies to the appropriate offices

This task would be considered an engineering task because one or more of the sub-tasks must be performed by an engineer. However, some of the sub-tasks could be characterized as "support" or "set-up" work; and some of the sub-tasks could be characterized as "principal" or "core" work. For example, sub-tasks a, c, d, e, i, j, and k are partly or completely "support" level work. That is, these are sub-tasks that could be delegated to a competent and properly trained administrative assistant, if one were available. On the other hand, items b, f, g, and h are "principal" level sub-tasks. They involve professional engineering, and they cannot be delegated to a support worker.

In general, the "support" or "set-up" sub-tasks of a professional or managerial task involve activities like searching, identifying, accessing, looking up, downloading, locating, transmitting or communicating documents, data or information; or they involve routine office skills like typing, filing, data entry, simple database queries, scheduling, copying, faxing, etc.

As you complete your time log, you will be asked to distinguish between time spent in "principal" level work and time spent in "support" level work.

Engineering and Program/Budget Analysis work also can be classified according to the minimum level of education, training and experience necessary to accomplish that work. In the HQUSACE, we can distinguish two levels of engineering and two levels of program/budget analysis work. These are:

- **Junior Engineer/Analyst Level Work:**
  This is work that can be done by a competent entry level engineer or analyst. This is someone with the educational background appropriate to the profession, who has had the appropriate training but who has less than several years experience. Junior engineering or analyst level work would include much of the routine engineering or analysis work performed in the HQUSACE. As a general guide, junior level engineering work would be professional engineering work that could be delegated to a GS-12 or lower engineer. Junior level program/budget analysis work would be analysis work that could be delegated to a GS 11 or lower analyst.

- **Senior Engineer/Analyst Level Work**:
  This is either engineering or analysis work of sufficient complexity, uniqueness, impact or importance that it should be handled by engineers or analysts with more than several years experience; or it is planning, directing and overseeing the engineering/analysis work of others. As a general guide, senior level engineering work would be professional engineering work that should be performed by GS 13 or higher engineers. Senior level program/budget analysis work would be analysis work that should be done by GS 12 or higher analysts.

Instructions

Please look at a time log sheet. The first column on the left lists the work categories discussed above. Listed first are the six major types of work (with engineering and program/budget analysis each separated into junior and senior level work), then the remaining activities which are sometimes a significant part of nearly everyone's day, then a catch-all "Other" category, and finally a row labeled TOTAL MINUTES.

The rest of the columns on the sheet are for your entries for each daily time period. The first and last of the columns on the sheet are for your entries for each daily time period. The first and last of these time periods are open ended (BEFORE 7:00 AM and AFTER 6:00 PM), and the others are exactly 1 hour long.

Before using the time log sheet to record your daily activities, you should review the "HQUSACE Dictionary of Work Categories And Example Tasks" (Appendix D). This will help you understand how each category is being defined for the purpose of this study. It will also ensure consistency in everyone's interpretation of the work categories.

Make your entries in the time log sheet at the end of each hour (or as close to that time as possible). Enter the number of minutes of each type of work for that time period in the appropriate space on the time log sheet.

The work categories listed in the time log sheet are intended to be complete and nonoverlapping. Therefore, the entries in each column should add up to 60 minutes. The only exception might be your first and last time periods of each day. For example, if you start work at 8:40 AM or leave work at 4:30 PM, then your first and last periods will contain only 20 minutes and 30 minutes, respectively. Please be sure to check your entries so that you have accounted for all your time in each column. In particular, you should account for all 60 minutes in each hour that is not the first or last hour of the work day.

In most cases, assigning your actual work in the time log categories should be straightforward. However, because work in HQUSACE is varied and complex, not every work activity can be explicitly anticipated by the time log. Therefore, in those cases, you should first review the document, HQUSACE DICTIONARY OF WORK CATEGORIES AND EXAMPLE TASKS, and then use your best judgement to assign your time to the closest category. Note that the listed tasks under each main type of work are intended only as examples. If the work that you did reasonably fits that category, you should log your time under that category even if your specific tasks are not explicitly listed. However, if none of the categories truly fit the work that you did, then use the "OTHER" category and add a brief explanation on the back of the sheet.

As a guide in assigning your time to the proper category, use the delegation test. Ask yourself: What is the lowest level to which this work could reasonably be delegated? If the work could be done by a secretary or clerk, then that work is administrative support work. If the work could not be done by a typical secretary or clerk, but it could be done by someone with some technical training (e.g., a PC specialist), then the work is technical support work. If the work is engineering work but it could be delegated to a junior engineer, then the work is junior level engineering work. And so on.

In posing and answering this delegation question, don't worry about current staffing limitations (that is, for example, a secretary could do this s but none are available). Simply assume that there is adequate staffing to handle any delegated work.

If you need help, or if you have any questions about filling out your time log sheet, you should call Beverly Thomas at 217/373-7284.

Please remember to make your entries on the form at the end of each hour, or as close to that time as possible!

Critical Information

Please do not make up data if you forget to log a certain period. Rather, we will extend your assigned 3-day logging interval so that a total of 3 days work is ultimately captured.

Please do not rely on your memory to fill out the form only once or twice a day, instead of once each hour. Extensive experience clearly shows that hourly logs, while an admitted inconvenience, are the best way to produce accurate results.

Do not be concerned if the days which you log do not appear to be "typical" for you. Do not adjust your data to make it look typical! We fully expect that no one's 3 days will be typical for him or her. However, by combining the results from all employees, the computed averages will be statistically reliable.

Do not be reluctant to log nonproductive time. This category helps us understand and quantify your need for additional support. Remember, our assumption is that you are getting your job done the best way possible, even if that entails spending a lot of time on nonproductive activities.

Your time log sheets will be treated confidentially. The time log sheets will be analyzed by an external consultant. Only summarized data (no names) will be reported.

Appendix D: Dictionary of Work Categories and Example Tasks

Project Administration

These are project-related tasks (research or reimbursable) that must be performed by the project manager. These can be referred to as "plan, program, schedule and budget" project. Some examples of this work include:

- Preparing PSBs or RDMIS
- Reconcile detailed cost listing
- Developing proposals for reimbursable work
- Developing CPAR, SBIR, QRIP programs
- Developing/planning USACERL-wide programs
- Providing technical advice to other government agencies
- Responding to ad hoc technical inquiries
- Developing material for/briefing to technical sponsors and/or DRD
- Developing (or assisting TL in developing) MADs or LRST strategies
- Responding to ad hoc Plans and Programs requests.

Project Execution

These are tasks that directly support a research or reimbursable project. These can be referred to as "execute" research or reimbursable project. Some examples of this work include:

- Evaluating the results of other research for applicability to your project
- Developing technical specifications and statements of work for contracts
- Preparing/refining detailed project plan
- Defending and justifying plans to senior management or colleagues
- Designing/refining models
- Designing/developing prototypes

- Computer programming, debugging, testing
- Reviewing/correcting subordinate's project-related work
- Assigning project responsibilities to subordinates
- Hiring/training personnel to work on project.

Technology Transfer

These are tasks that lead to the dissemination of information about research or reimbursable project. Some examples of this work include:

- Presenting research findings to users/customers/other researchers
- Participating in project-related conferences
- Providing training to users
- Writing technical reports, PR materials, or technical articles
- Writing technical and/or user documentation
- Preparing/revising technology transfer plan documents.

Technical Support Tasks

These are support tasks which demand some technical skill or knowledge. Some of these tasks are done by nearly everyone. The key question to ask is, "Is this work related to my project?" These tasks should not be directly related to your reimbursable or research project.

Some examples include:

- Computer problem solving
- Installing/fixing/configuring computer hardware or software
- Doing routine maintenance on computer hardware
- Performing database maintenance
- Providing formal or informal computer training for others
- Using a PC to produce reports, or to query or update a database
- Performing statistical analyses
- Producing technical charts or graphs.

Administrative Support Tasks

These are nontechnical tasks that can be performed by someone with general office skills and some on-the-job training. Some of this work is done by nearly everyone. Some examples include:

- Opening, reading, routing mail and correspondence
- Routing requests and information to others
- Responding to requests for routine information
- Preparing time sheets
- Preparing status reports, e.g., Weekly Accomplishments
- Data entry, e.g., Inventory
- Answering phone, routing calls, taking messages
- Reading company memos, policies, new, etc.
- Filing documents, forms, etc
- Faxing
- Scheduling meetings
- Making travel arrangements
- Copying, collating and distributing materials
- Ordering hardware/software/supplies via credit card, etc.
- Doing vacation/sick leave paperwork
- Preparing travel vouchers
- Cleaning office or team area
- Preparing simple graphs and charts
- Escorting visitors.

Serving on or Supporting Government Committees

This refers to all the time that you spend working on government committees that are not project-related. This work might be done alone or in meetings with others. Some examples of these tasks include:

- Developing agendas
- Participating in TQM activities, e.g., PATs or Focus Groups
- Reviewing minutes
- Setting schedules
- Attending meetings
- Gathering or reviewing information
- Preparing reports or presentations
- Follow-up phone calls, memos, etc.

Professional Development

This refers to all the time you spend gaining, maintaining or updating the knowledge and skills necessary to do your job. This includes all formal and informal training and education. This work might be done alone or in group sessions. Some of this work is done by nearly everyone. Some examples include:

- Reading professional or trade literature
- Learning or experimenting with computer software and hardware
- Attending seminars, conferences, workshops or training classes
- Receiving informal training
- Participating in professional organizations/committees.

Nonproductive Time

This refers to work time during which no work gets done. Despite everyone's best efforts, nonproductive time is an almost inevitable part of each day. Some typical nonproductive activities include:

- Walking to a meeting and waiting for it to start
- Searching through files for a lost document
- Searching for someone or something
- Waiting in line to use a copy or Fax machine
- Waiting to see someone
- Telephone tag
- Fire drills.

Community Service Activities

This refers to all the time that you spend during working hours engaged in community support activities as a representative of the government. This work might be done alone or in meetings with others. Some examples of these tasks include:

- Fund raising calls, e.g., CFC
- Attending public meetings
- Administrative work on behalf of a community organization.

Travel Time

This refers to time that you spend traveling on company business during normal working hours, during which time you are not getting any work done. If, for example, you are getting work done while you are riding in a car or airplane, then you should log that time under the appropriate work category. Do not include intra-building transit time in this category (log that time in the nonproductive category), but do include inter-building transit time (e.g., going from Building #1 to Building #3).

Personal Time

This refers to the nonwork periods during the work day. Examples include:

- Lunch time
- Coffee breaks
- Networking/personal discussions
- Restroom breaks
- Personal phone calls
- Personal errands.

Completing the Time Log

This refers to the time you spend reading these instructions and filling out time log sheets. If you spend time referring back to these instructions or documents, getting help in completing the time log, distributing or collecting these forms or reviewing them for completeness, or helping someone else with their form, log that time under Completing Time Log, as well.

Meetings

Use this area to indicate any meetings that do not fall under other categories. For example, SAEDA security briefings, Division meetings, information meetings about some work-related (but nonproject) related topic such as the new USACERL phone system, etc. Many of your meetings that are not project related will be logged either here or under "Professional Development."

Other

Please note—on a piece of paper or separate file—any activities that you have performed during the past hour that do not fit under any other category described above. Record the # of minutes spent in this undefined category in the "Other Type of Work" section.

USACERL DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CECC-R
ATTN: CECW
ATTN: CERM
ATTN: CEMP-MC
ATTN: CERD-ZA

CECPW 22310-3862
ATTN: CECPW-E
ATTN: CECPW-FTT
ATTN: CECPW-ZC

US Army Engr District
ATTN: Wilmington 28402

US Army Engr Division
ATTN: Library (12)

Defense Distribution Region East
ATTN: DDRE-WI 17070

US Army Materiel Command (AMC)
Redstone Arsenal 35809
ATTN: DESMI-KLF
Rock Island Arsenal 61299
ATTN: SMCRI-EH
ATTN: SMCRI-TL

FORSCOM
Fort Hood 76544
ATTN: AFZF-DE-AES Engr

TRADOC
Fort Eustis 23604
ATTN: DPW
Fort Sill 73503
ATTN: ATZR-E

CEWES 39180
ATTN: Library

CECRL 03755
ATTN: Library

Engr Societies Library
ATTN: Acquisitions 10017

Defense Logistics Agency
ATTN: DLA-WI 22304

American Public Works Assoc. 64104-1806

US Gov't Printing Office 20401
ATTN: Rec Sec/Deposit Sec (2)

Nat'l Institute of Standards & Tech
ATTN: Library 20899

Defense Tech Info Center 22304
ATTN: DTIC-FAB (2)

41
+1
9/95